

BELLCOMM. INC.

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SUBJECT: Effect of Failure to Deploy of
a Workshop Solar Array on CMG
Control Capability - Case 620

DATE: February 18, 1971

FROM: W. Levidow

MEMORANDUM FOR FILE

A failure of the deployment mechanism of one of the Workshop solar arrays on the Skylab Orbital Assembly, alters the vehicle mass properties and the gravity-gradient bias momentum. This memorandum investigates the ability of the Control Moment Gyros (CMGs) to execute the required momentum dump maneuvers and control the solar inertial attitude in this failed configuration.

The gravity-gradient bias momentum is proportional to the difference (ΔI_x) between the largest and the intermediate principal moments of inertia. The inertia values (slug-ft²) for the normal configuration and two configurations with deployment failures are shown below.

Arrays	I_{xx}	I_{yy}	I_{zz}	ΔI_x
Both Deployed*	725040	4615430	4558217	57213
Position II Failure†	663150	4638843	4549404	89439
Position IV Failure†	666677	4642140	4547220	94920

With both arrays deployed, the X-axis bias momentum has a calculated maximum value of 303 ft-lb-sec. In addition to gravity-gradient bias momentum, a conservative model of venting and leakage torque yields additional bias momentum of 275 ft-lb-sec along the X axis and over 1000 ft-lb-sec in the YZ plane.** Aerodynamic torque adds about 100 ft-lb-sec more, perpendicular to the orbital plane.

Because of its larger ΔI_x , the Position IV array failure is the worst failure mode. It results in a calculated maximum X-axis bias momentum of 503 ft-lb-sec, an increase of 200 over the non-failure case.

* S&E-ASTN-SAE Program WP97B 1-7-71 Run 47A Event 7.

**Smith, P. G., "Skylab Venting Propulsion," Bellcomm Technical Memorandum TM-70-1022-18, December 22, 1970.

Smith, P. G., "Skylab Leakage Propulsion Models," Bellcomm Technical Memorandum in preparation.

† Calculated by W. W. Hough, Bellcomm, Inc.

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Hence the effect of a non-deployed array is to increase the maximum X-axis bias momentum by about 35% and increase the magnitude of the total momentum to be dumped by 20% at worst.

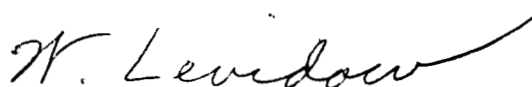
A simulation of the CMG variations and the dump maneuvers at various values of Beta, sun line to orbital plane angle, yields the following typical data for an orbit.

Arrays	Maximum Momentum Excursion* (ft-lb-sec)	Maximum Dump Maneuver Angle from Solar Inertial (degrees)
Both Deployed	3990	10.5
Position IV Failure	4080	12.9

The difference is not significant.

Conclusion

The failure to deploy of a workshop solar array will not impair the capability of the CMGs to control the Orbital Assembly in solar inertial attitude and execute the required momentum dump maneuvers.



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*The limit of momentum excursion from zero is about 6750 ft-lb-sec for 3 CMGs.

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